MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2016/2017

DCE5028 – ELECTRICAL MACHINES AND POWER SYSTEMS

(Group: E5)

10 OCTOBER 2016
9.00 a.m. – 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **5** pages (**4** pages with **4** questions and **1** page for appendix).

2. Answer **ALL** questions. All necessary working steps must be shown.

3. Write all your answers in the answer booklet provided.

Answer ALL questions (100 marks)

Question 1

a)

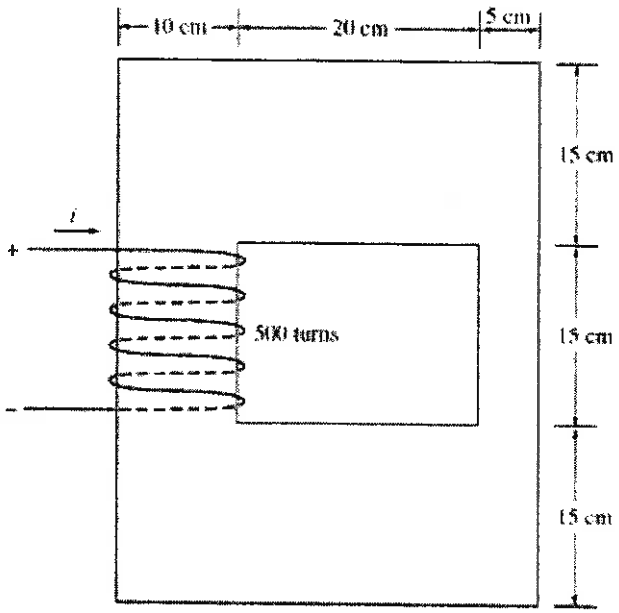


Figure 1

A ferromagnetic core is shown in Figure 1. The depth of the core is 5 cm and all other dimensions are shown in the figure. The number of turns on the coil is 500. Assume the relative permeability of the core is 1000:

i. Draw the equivalent circuit for Figure 1. [2 marks]

ii. Find the value of current that will produce a flux of 0.003 Wb. [9 marks]

iii. What is the flux density at the top of the core? [2 marks]

iv. What is the flux density at the right side of the core? [2 marks]

Continued...

b) Three impedances of 4 + j3 Ω are delta connected and tied to a three-phase 208 V power line. Find:

i. the phase current. [2 marks]

ii. the line current. [1 mark]

iii. the total real power. [2 marks]

iv. the total reactive power. [2 marks]

v. the total apparent power. [2 marks]

vi. the power factor. [1 mark]

[Total = 25 marks]

Question 2

a) A 240 V separately excited dc motor has an armature resistance of 0.68 ohm and draws a full-load current of 24 A at a speed of 100 rpm. Calculate:

i. the back emf. [2 marks]

ii. the output power developed. [2 marks]

iii. the torque developed. [2 marks]

b) When a dc generator is being driven at 1200 rpm, the generated emf is 125 V. What will be the generated emf if

i. the field flux is decreased by 10% with the speed remains unchanged? [2 marks]

ii. the speed is reduced to 1100 rpm, the field flux remains unchanged ? [2 marks]

c) State three losses in DC motor. [3 marks]

d) Transformers can be classified by their frequency range. Give any two of them. [2 marks]

Continued...

e) Three single phase, 10 kVA, 460/120 V, 60 Hz transformers are connected in delta – wye to form a three-phase transformer of 460/208 V. The equivalent impedance of each transformer referred to the high-voltage side is 1.0 + j2.0 Ω. The transformer delivers 20 kW at 0.8 leading power factor. Determine

i. the transformer phase current in LV and HV side. [5 marks]

ii. the primary voltage (V_1). [3 marks]

iii. the voltage regulation. [2 marks]

[Total = 25 marks]

Question 3

a) State two types of rotor construction for induction motor. [2 marks]

b) A 4-pole 400 V, 50 Hz, three-phase induction motor runs at 1440 rpm at 0.88 lagging power factor and delivers 10.817 kW. The stator loss is 1060 W, and the friction and windage losses are 375 W. Calculate:

i. the slip. [3 marks]

ii. the rotor copper loss. [3 marks]

iii. the line current. [5 marks]

iv. the efficiency of the motor. [2 marks]

Continued...

c) A 440 V three-phase wye- connected synchronous motor has a synchronous reactance of 1.5 Ω per phase. The field current has been adjusted so that the torque angle δ is 28° when the power supplied to the motor is 90 kW.

i. What is the magnitude of the internal generated voltage E_A in this machine?

[4 marks]

ii. What are the magnitude and angle of the armature current in the machine?

[3 marks]

iii. Calculate the motor power factor. [1 mark]

iv. If the field current remains constant, what is the maximum power this motor can supply?

[2 marks]

[Total = 25 marks]

Question 4

For the diagram shown in Figure 2, draw the per unit impedance diagram. Show all necessary calculations in order to draw the complete diagram. Select the transmission line (20 + j80 Ω) rating of 100 MVA, 154 kV as base quantity.

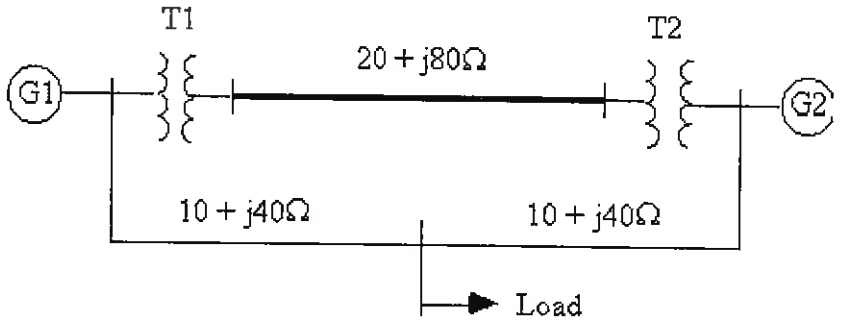


Figure 2

G1: 50 MVA, 13.8 kV, 15% T1: 60 MVA, 13.2/161 kV, 10%

G2: 20 MVA, 14.4 kV, 15% T2: 25 MVA, 161/13.2 kV, 10%

Load: 1.15 + j1.53 Ω

[25 marks]

[Total = 25 marks]

End of Page.

Appendix

Magnetic Circuit

$\mathbf{F} = Ni = \Re_{eq}.\Phi = Hl$ $\quad \Re_c = \frac{l_c}{\mu_c A_c}$ $\quad B = \frac{\Phi}{A_c}$

$\mu_c = \mu_r \mu_0$ $\quad \mu_0 = 4\pi \times 10^{-7}$ H/m

$E = \frac{\Phi ZN}{60} \times \frac{P}{A}$ $\quad \tau = \frac{1}{2\pi}\left(\frac{P\Phi Z}{A}\right) I_a$ $\quad P_M = \tau.\omega = EI_A = P_E$

DC Machines

$V_t = E - R_a I_a$ (Shunt Generator)

$V_t = E + R_a I_a$ (Shunt Motor)

$\eta = \frac{P_{out}}{P_{in}} \times 100$

Armature copper loss = $I_a^2 R_a$ $\quad$ Field copper loss = $I_f^2 R_f$

Transformer

$a = \frac{E_1}{E_2}$ $\quad V_2 = E_2 - I_2(R_{e2} + jX_{e2})$ $\quad R_{e1} = R_1 + a^2 R_2$ $\quad R_{e2} = \frac{R_1}{a^2} + R_2$

Voltage regulation = $\frac{E_2 - V_2}{V_2} \times 100$ $\quad X_{e1} = X_1 + a^2 X_2$ $\quad X_{e2} = \frac{X_1}{a^2} + X_2$

Three-phase Circuits

Δ: $\quad V_L = V_\phi$ $\quad I_L = \sqrt{3} I_\phi$

Y: $\quad V_L = \sqrt{3} V_\phi$ $\quad I_L = I_\phi$

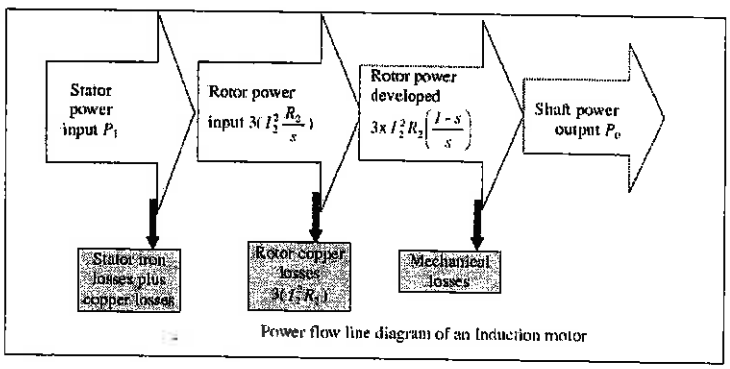
$S = 3V_\phi I_\phi = \sqrt{3} V_L I_L$

$P = 3V_\phi I_\phi \cos\theta = \sqrt{3} V_L I_L \cos\theta$

$Q = 3V_\phi I_\phi \sin\theta = \sqrt{3} V_L I_L \sin\theta$

Induction Motor

$n_s = \frac{120f}{p}$ $\quad s = \frac{n_s - n}{n_s}$


Stator power input P_i
Rotor power input $3(I_2^2 \frac{R_2}{s})$
Rotor power developed $3s I_2^2 R_2 \left(\frac{1-s}{s}\right)$
Shaft power output P_o
Stator iron losses plus copper losses
Rotor copper losses $3(I_2^2 R_2)$
Mechanical losses
Power flow line diagram of an Induction motor

Synchronous Machines

$X_S = \frac{E_{open-circuit}}{I_{short-circuit}}$

$P = \frac{E_c V}{X_s} \sin\delta$

$E_c = V - I_a(Ra + jX_s)$

Per-unit Value

$$per-unitZ_{new} = per-unitZ_{given}\left(\frac{basekV_{given}}{basekV_{new}}\right)^2\left(\frac{basekVA_{new}}{basekVA_{given}}\right)$$